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SOLUTION OF PROBLEM 120. (SEE VOL. III, P. 132.)

Editor Analyst:

As you requested me to examine Prob. 120 under the supposition that it should have been written

$$\text{Given}\left\{\begin{aligned}&[x^2+xy+y^2]^{\frac{1}{x+y}}=m,\\&[x^2-xy+y^2]^{\frac{1}{x-y}}=n,\end{aligned}\right\}\text{ To find } x \text{ and } y,$$

I submit the following solution:

Clearing the equations of fractions and multiplying the first by $x—y$ and the second by $x+y$, and reducing, we get

$$(n-m)x^3=(n+m)y^3\,;$$

whence we find

$$x=\left(\frac{n+m}{n-m}\right)^{\frac{1}{3}}.y,\quad y=\left(\frac{n-m}{n+m}\right)^{\frac{1}{3}}.x.$$

Substituting for y and x, respectively, in the first and second eq's, we get

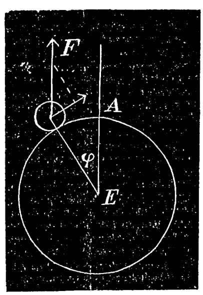
$$x=m.\frac{(n^2-m^2)^{\frac{1}{3}}+(n+m)^{\frac{2}{3}}}{(n+m)^{\frac{2}{3}}+(n^2-m^3)^{\frac{1}{3}}+(n-m)^{\frac{2}{3}}},$$

$$y=m.\frac{(n^2-m^2)^{\frac{1}{3}}+(n-m)^{\frac{2}{3}}}{(n+m)^{\frac{2}{3}}+(n^2-m^3)^{\frac{1}{3}}+(n-m)^{\frac{2}{3}}}.$$

GEORGE H. HARVILL.

Bonner, La., Jan. 24, 1880.

PROB. 281. (SEE P. 190, VOL. VI.) SOLUTION BY PROF. DE VOLSON WOOD.—Assuming that the attraction of the sun is constantly parallel to the line of centres of the earth and sun, and of constant intensity F, then will $F\sin\varphi$ be the force which causes the ball to roll, φ being the angular distance on the earth of the ball from the line of centres. Let θ be the angle through which the ball has rolled when its angular dist. from the line of centres is φ and t the corresponding time, m the mass of the ball, v the present velocity of the earth in its orbit, D the distance between the earth and sun, R the radius of the earth, r the radius of the ball and k its radius of gyration and ω the angular velocity of the earth. Then we have



$$F=m\frac{v^2}{D},\tag{1}$$

$$\frac{d^2\theta}{dt^2}=\frac{Fr\sin\varphi}{mk^2},\tag{2}$$

$$R\omega t=R\varphi+r\theta.\tag{3}$$

Differentiating (3), $R\omega dt = Rd\varphi + rd\theta.$ (4)

Differentiating again, $0 = Rd^2\varphi + rd^2\theta;$

$$\therefore d^2\varphi = -\frac{r}{R}d^2\theta = -nd^2\theta. \quad (5)$$

From (4) $dt = \dfrac{d\varphi + nd\theta}{\omega}.$ (6)

Equations (5) and (6) reduce (2) to

$$-\frac{m\,\omega^2 k^2}{nrF}\cdot\frac{1}{\sin\varphi}\cdot\frac{d^2\varphi}{d\theta^2} = \frac{d\varphi^2}{d\theta^2} + 2n\frac{d\varphi}{d\theta} + n^2.$$

The integral of this (which I have not yet found in finite terms) gives

$$\varphi = f(\theta),$$

and this in equation (3) gives θ in terms of t. As t is known (12 hours) θ becomes known and hence φ is known; the latter of which makes known the distance of the ball from the line of centres. The relative velocities will be $rd\theta \div R\omega dt.$

The values of the fixed constants are, approximately, $D = 92{,}500{,}000$ miles, $v = 68{,}000$ miles per hour, $R = 25{,}000 \div 2\pi$ miles, $r = 2\frac{1}{2}$ miles, $k^2 = \frac{2}{5}r^2$, $m = (r^3 \div R^3)$ times the mass of the earth, $\omega = 2\pi \div (12 \text{ hours})$. In using these the corresponding quantities must all be reduced to the same unit. The value of F is about 1,300,000,000 gross tons.

[This problem, as published, in the absence of Mr Schneider's diagram that accompanied his manuscript, leaves the direction of the sun from the point A, indeterminate. It appears, however, from Mr. Schneider's figure that he contemplated the attractive force as being in a direction from A, *opposite* to that indicated by the arrow in the foregoing figure; hence equation (3) should be written $R\omega t = R\varphi - r\theta$.

If we multiply (2) by n, then substitute in (2) for $nd^2\theta$ its value $d^2\varphi$ from (5), (2) will become

$$\frac{d^2\varphi}{dt^2} = \frac{r^2F}{mk^2R}\sin\varphi.$$

Multiplying this eq. by $2d\varphi \div dt$, integrating once, introducing the correction and extracting the square root of both members, we get

$$\frac{d\varphi}{dt} = \frac{r}{k}\sqrt{\left(\frac{2F}{mR}\right)}\cdot\sqrt{(a - \cos\varphi)}. \quad (7)$$

Substituting for dt in (7) its value from (6), reducing and integrating again, we get

$$\theta = \frac{R}{r}\varphi - \frac{\omega kR}{r^2}\sqrt{\left(\frac{mR}{2F}\right)}\int\frac{d\varphi}{\sqrt{(a - \cos\varphi)}}$$

which is an elliptic function of the first order.—Ed.]